STRATEGY RESEARCH PROJECT

ARMY AIR DEFENSE ARTILLERY TRANSFORMATION MANAGING LIMITED RESEARCH AND DEVELOPMENT FUNDING

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ABSTRACT

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The U.S. Army depends on modern technological developments to remain the dominant global fighting force of the future. Real U.S. Research and Development (R&D) investment declines while the rate of technology growth multiplies. The rapid pace and eventual success of U.S. Army Air Defense Artillery ADA transformation, in support of the Army's transformation, is highly dependent upon wise stewardship of limited funding and the application of re-engineered acquisition processes. Critical acquisition activities include leveraging the technology base, streamlining acquisition, applying Military and Commercial Off the Self (MOTS/COTS) products, and identifying elegant technologies to replace "traditional" brute force solutions. These developments suggest the U.S. Army and ADA must develop strategies to capitalize on every R&D dollar and each acquisition initiative for success in transitioning to the Objective Force. This research paper will explore and identify the critical acquisition initiatives and suggest strategies for the management of the R&D budget in order to enable successful Army ADA transformation.

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> "The Army is well into the transformation process that will take it from a Cold War force to the objective force. It will have to adjust its modernization strategy based on resource constraints, but it can control its destiny."
>
> — LTG Paul Kern

The U.S. Army depends on modern technological developments to remain the dominant global fighting force of the future. Real U.S. research and development (R&D) investment declines while the rate of technology growth multiplies. Increasing demands on the finite U.S. Government budget and the passage of the Balanced Budget Act cause a continual decline in the amount of real money the U.S. invests in R&D. This happens during a time that defense contractors see their stock values decrease and find themselves searching to free equity. Reduced stock values result in decreased industry independent R&D investment. These developments suggest that the Army, cooperating with the Department of Defense (DoD), must develop strategies to capitalize on every dollar spent to maintain our technological edge.

The rapid pace and eventual success of Army Air Defense Artillery (ADA) transformation is highly dependent upon wise stewardship of limited funding. Critical acquisition activities include leveraging the technology base, applying Military Off the Shelf Technologies and Commercial Off the Shelf Technologies (MOTS/COTS), streamlining acquisition processes, and identifying and applying "elegant" technologies to replace "traditional" brute force lethality and survivability solutions. These activities are strictly regulated within the DoD via extensive and time-consuming requirement development and approval processes, governing acquisition guidelines, and strict oversight hierarchies. Transformation initiatives are schedule driven and, in order to be successful, must operate within the established acquisition guidance, yet not lose critical time just to satisfy the process itself. This research paper addresses specific challenges facing the Army, focuses on ADA supporting the Chief of Staff's transformation initiatives

considering the current budget situation, and offers specific strategies and recommendations for effectively increasing available R&D funding for modernization of ADA systems.

BACKGROUND

The R&D budget limits the Army's ability to develop and purchase new and innovative advances and transform itself into a force capable of facing the threats of the 21st century. The Army budget has decreased by 37 percent since 1989.[1] For over a decade the Army took a "procurement holiday," postponing the purchase of new equipment and modernization advances through technology. At the same time, the Army faced unprecedented wear and tear on its existing equipment. In an overall effort to control the budget deficit, the Federal Government abstained from replacing worn-out and obsolete military equipment and reduced its investment into research and development. Much of the Army's current equipment was purchased during the "Reagan Era" of the 80's; some systems are even older. Now the Army faces a "bow wave" of purchasing requirements to replace old equipment and incorporate the latest technological advances to prepare to face new missions and challenges.

ADA units are critical to the Army's early entry and force projection mission areas. Doctrine requires force protection from air and missile threats via a redundant, multi-layered, air and missile defense (AMD) organized into upper and lower tier elements. The Army contribution to the upper tier will consist of a theater-class system currently in development known as the Theater High Altitude Air Defense (THAAD) system. THAAD will field in the late 2000s. Army lower tier consists of the combat proven PATRIOT missile system – soon to be equipped with PATRIOT Advanced Capability–3 (PAC-3) hit-to-kill (HTK) missiles designed specifically for enhanced performance against ballistic missiles. The Navy is also developing upper and lower tier systems, for fleet and littoral AMD. AMD is typically extremely high on the regional Commander in Chief's (CINCs) priority list to protect air and sea ports of entry and military personnel/civilian population centers. PATRIOT's suitability for AMD in a transformed

force must be addressed through modernization in two areas: deployability/mobility, and affordability.

PATRIOT was designed in the1980s for site-centered protection of static assets like airfields. It was not designed to be rapidly deployable or highly mobile. Without major disassembly, PATRIOT's bulky equipment requires a U.S. Air Force C-5 for transport by air. It is self-transportable by road, but its bulky tractor and trailer configuration cannot keep up with the maneuver force pace. PATRIOT will therefore not meet the AMD requirement to arrive in theater, provide base defense, and further provide continuous AMD of the joint maneuver forces after they transition outside of the rear area. PATRIOT re-deployment, both inter- and intra-theater requires time and lift assets that will not typically be available.

The PAC-3 missile is designed to be operationally effective against the wide array of complex targets facing the maneuver forces on the modern battlefield. At issue is PAC-3's cost effectiveness against the numerous simple and relatively inexpensive systems opposing forces will deploy. These targets include short-range battlefield rockets, called large caliber rockets (LCRs), which are capable of delivering various payloads ranging from high explosive to weapons of mass destruction (WMD). ADA commanders protecting against LCRs, Unmanned Aerial Vehicles (UAVs), and other inexpensive WMD delivery systems require efficient countermeasure systems that are highly effective, but also inexpensive, unlike the "silver bullet" - a full up PAC-3 missile. PAC-3 missiles are expected to eventually drop to around $2 million, but early production deliveries will cost more. The Army initiated cost reduction measures and expects average unit cost decreases as production quantities increase. However, PAC-3 missiles will never be considered "cheap". The Army must explore alternative, low-cost solutions to counter the proliferating short-range, low-cost threats to the maneuver forces. Potential technical solutions include both directed energy (DE) and kinetic energy (KE) systems.

The transformation dilemma facing Army leadership concerning ADA capability is how to best spend scarce R&D funds to meet its requirement for a cost effective AMD solution.

Analysis must include rapid modernization alternatives for the current AMD systems and continued research, development and deployment of a next generation solution such as DE or KE systems.

BUDGET ISSUES

R&D funding for medium to high altitude AMD systems is managed by the Ballistic Missile Defense Organization (BMDO), an Office of the Secretary of Defense (OSD) reporting element. While there has been internal discussion concerning the magnitude of previous Army contributions to Army managed and manned systems such as PATRIOT, the vast majority of AMD R&D funding comes directly from OSD. Since significant Army funds are not now allocated for AMD system developments, other than Short Range Air Defense (SHORAD), the Army is often perceived as lacking ownership or interest for AMD modernization. It must show significant user operational support for R&D that will affect the transformation posture of ADA systems, while walking a fiscal tightrope calling for specific Army funding contributions to achieve its objective force. In a zero sum environment, Army funding support for ADA modernization may come only as the result of a re-allocation of funding from other R&D projects and an accompanying modification of funding priorities. The Army's ADA funding dilemma, therefore, is reluctance to allocate scarce R&D dollars within a mission area considered the responsibility of OSD. Without the commitment of specific Army funding, it is difficult for the Army to influence OSD decisions on AMD developments including relative deployment priorities.

Army specific funding priorities are shaped by many of the same concerns experienced at the OSD level: the desire and requirement to push ahead with advanced technologies must be weighed against maintaining and modernizing existing and proven platforms. OSD/BMDO considers the potential of advanced "leap ahead" systems like the Space Based Laser versus "traditional" National Missile Defense (NMD) alternatives in much the same manner.

The current administration recognizes the funding shortfall and is looking for ways to alleviate the problem. In a September 1999 speech at the Citadel, President Bush noted a window of opportunity to skip "a generation of technology." [2] He, like most civilian and military leaders, recognizes the daunting task faced by this nation to keep our military modern and capable of facing the threats of the 21st century and is looking for innovative ways of doing this. President Bush suggests skipping the purchase of some items so the DoD can work past this "bow wave" of requirements.

The Center for Strategic and Budgetary Assessments, a nonpartisan defense think tank, reported the military must spend at least $85 billion a year to buy everything that is currently in the procurement pipeline. The 2001 defense budget provides the authority to spend $60 billion, leaving a 29 percent deficit.[3] The center's report highlights how much ground must be made up and the fact that solutions will not come easily. In the Citadel speech, Bush said his first goal for the military is "to order an immediate review of overseas deployments, not necessarily to withdraw troops but to redefine objectives." Bush's second goal is "to improve defenses against terrorism and the spreading weapons technology, which includes building a national missile defense system." Bush's third goal – and the most controversial – calls for "restructuring military forces and weapons to take advantage of new technologies, which could require skipping the production of one generation of weapons."[4]

FUNDING SITUATION

How did the U.S. get into a situation where the newly elected Commander in Chief is so concerned with funding the DoD that he is considering skipping a generation of technology? In March 1998, the Center for Strategic & International Studies (CSIS) published a report on the Defense Industrial Base (DIB) stating, "... in the first quarter of the 21st century, the Department of Defense is likely to require approximately 4.3% of gross domestic product (GDP) in order to maintain its current force structure over the long-term, including the modernization of that force

with new weapon systems."[5] CSIS highlights the fact that after 13 years of decline the DoD budget finally increased from Fiscal Year (FY) 2000 to FY 2001. Compared to FY 1985 the FY 2001 budget actually is 66 percent less in constant dollars. A reduction of this magnitude makes it very easy to understand why the DoD was forced into a "procurement holiday".

The following CSIS chart shows that the R&D budget will remain approximately level through 2005. In fact, the FY 2001 DoD budget is projected to be at three percent of GDP, and according to CSIS, leaves the Defense Department unable to purchase all of its current advanced technology developments.

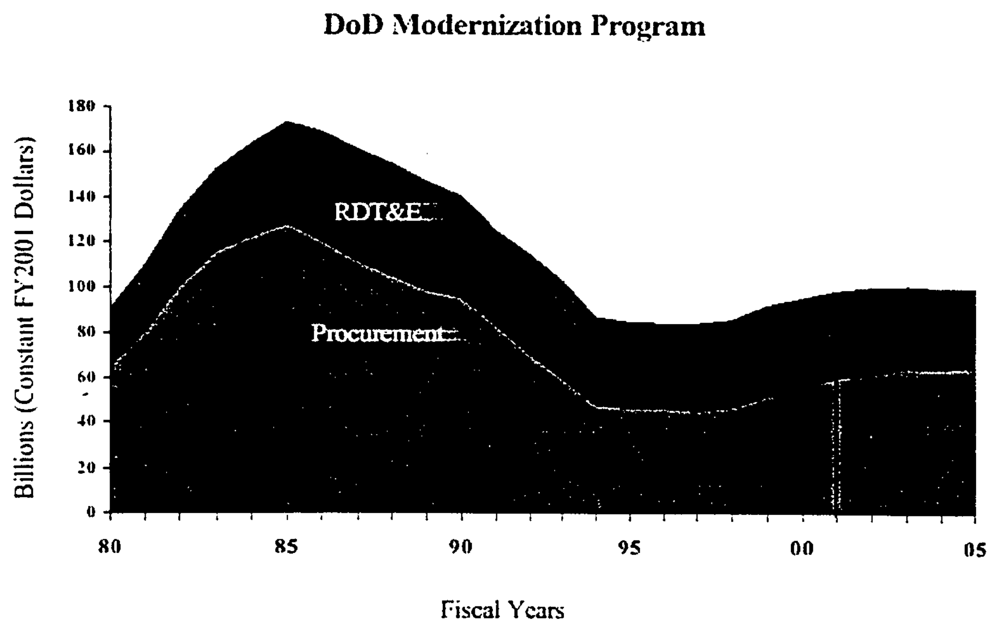

FIGURE 1: DOD MODERNIZATION PROGRAM[6]

With so much equipment in the procurement pipeline and aging equipment on hand this R&D budget will fall short of the Army's needs and keep it from funding ADA transformation initiatives.

TRANSFORMATION INITIATIVES

The Army intends to transform five to eight brigades into Interim Brigade Combat Team(s) (IBCTs) using off-the-shelf (OTS) equipment. The primary reasons for using OTS equipment is to reduce fielding time and to cut R&D costs. The Army does not have the budget to support the existing (Legacy) force, purchase new equipment for the Interim Brigades, and fund large amounts of R&D to develop the Objective Force. During recent confirmation hearings, Secretary of Defense (SECDEF) Donald H. Rumsfeld said, "We cannot allow the effectiveness of our military forces to degrade while we are modernizing. The U.S. military needs to get on a new path that will permit the rapid introduction of advanced technology that can materially increase military effectiveness and decrease the cost of operating and maintaining those forces."[7] He was referring to the huge operations and maintenance (O&M) budget the Army needs to support the aging Legacy Force equipment and the need to cut acquisition time for the latest in advanced technology so we can reach the Objective Force. If President Bush decides to skip a generation of technology, the Army's IBCTs are at risk of cancellation. Likewise, modernization of current ADA systems may stop.

NEW ADMINISTRATION

During the 2000 presidential race, both candidates proposed increasing the DoD budget. They discussed the R&D and procurement budgets and recognized quality of life needs like higher pay, better medical care, and improved housing. The new administration committed itself to a comprehensive review of offensive and defensive weapon system requirements, to include missile defense, and the quality of life issues necessary to transition the DoD into a force appropriate for the 21st century. The implications to the Army and its ADA community include delaying critical procurement decisions, and given the short timeline for transformation,

causing significant schedule slips. From a more positive standpoint, the review is likely to recommend additional funding of critical systems supporting transformation.

RELEVANCY OF ADA

Today's proven AMD elements are crucial components of force protection for joint and combined maneuver forces, deployed units, and vulnerable activities necessary to accomplish our national security objectives. These include static protection of airfields, seaports, logistic support activities, and forward deployments such as the standing force in Saudi Arabia and Bosnia. Desert Storm lessons learned demonstrated that while PATRIOT provided protection for the build up activities and civilian population centers, it was unable to keep pace with the maneuver forces. The Army's Chief of Staff (CSA), General Eric K. Shinseki, envisions an unrivaled operational pace without leisurely preparation time. Under that scenario, today's bulky PATRIOT system cannot be operationally available for AMD, and protection can only be provided via organic SHORAD assets and relying on other service's assets.

With the fielding of PAC-3 missiles comes the operational capability to engage and defeat the majority of the air and missile threats encountered in a static deployment situation. However, maneuvering forces may not be protected, and in fact, PATRIOT may not even make it to the fight; it places great demand on strategic lift assets that the regional CINC is likely to allocate to other elements of combat power. For the AMD force to remain relevant, it must become lighter, strategically deployable and tactically mobile. To this end, the Army supports developing the next generation of AMD, the Medium Extended Air Defense System (MEADS). MEADS is a cooperative program with Germany and Italy that uses the PAC-3 missile as its interceptor. Although MEADS replaces PATRIOT as it fields, PATRIOT remains in the force until the 2025 time frame and will require continuous recapitalization and selected modernization.

THE THREAT

What is the threat that requires investing three percent or more of GDP to pay for this nation's military defense? SECDEF Rumsfeld recently noted, " ... the U.S. today faces 'a dangerous and untidy world' that includes threats not thought of in the cold war, like cyber attacks and ballistic missiles from emerging nuclear powers."[8] He and the intelligence agencies recognize the dangers facing our nation and its interests. Along with those threats identified by the SECDEF, there are the threats of information warfare and chemical and biological weapon attacks from any of a number of sources.

Most U.S. citizens recognize the dangers from China and the rogue states of Iraq, Iran, Libya, and North Korea, but there are others like Pakistan and Syria or even the single terrorist. In open press, U.S. intelligence agencies reported China's rapid buildup of conventional and nuclear forces. In January 2001, China conducted a second test flight of a rocket capable of placing a spacecraft into Earth orbit.[9] Other reports state that China is buying U.S. weapons technology illegally through front companies in Hong Kong and Singapore. China purchased radiation-hardened integrated circuits and American-made communications-test equipment. China also sells missile equipment to Iraq and Iran, advancing those countries' offensive military capabilities.[10]

Iran is preparing for another flight test of its new intermediate range ballistic missile. The Shahab-3, a single warhead, mobile missile with a range of about 800 miles and believed by U.S. intelligence to be the first Iranian missile that could carry a nuclear warhead.[11] The Pentagon reported that Iraq is working on two short-range missiles to help them develop their long-range missile capability. Pakistan is nearing the point where they are going to have an excess of fissile material that could be sold to fabricate nuclear weapons.

Terrorists can strike many places throughout the world, including U.S. overseas assets. Secretary Rumsfeld correctly expresses his concern over post cold war threats. The U.S. must continue to invest in advancing its weapons technology to remain the pre-eminent fighting force

and help guard U.S. interests, swiftly reacting to the newest of threats. Ultimately, an investment of three percent GDP may not be enough to purchase the advanced technologies required.

The above summary of strategic WMD targets highlights the requirement for some form of National and Theater Missile Defense force. Figure 2 describes in detail what is anticipated to face a maneuver force commander in "the next Desert Storm." Joint force airpower is expected to maintain air superiority, but will not be sufficiently effective against the array of WMD and conventional warhead capable threats that may arrive in theater. Equipped with countermeasures, or more alarmingly, combinations of countermeasures, all categories of threat systems will have the potential to be highly lethal and disruptive; most have been offered for sale at major arms shows around the world.

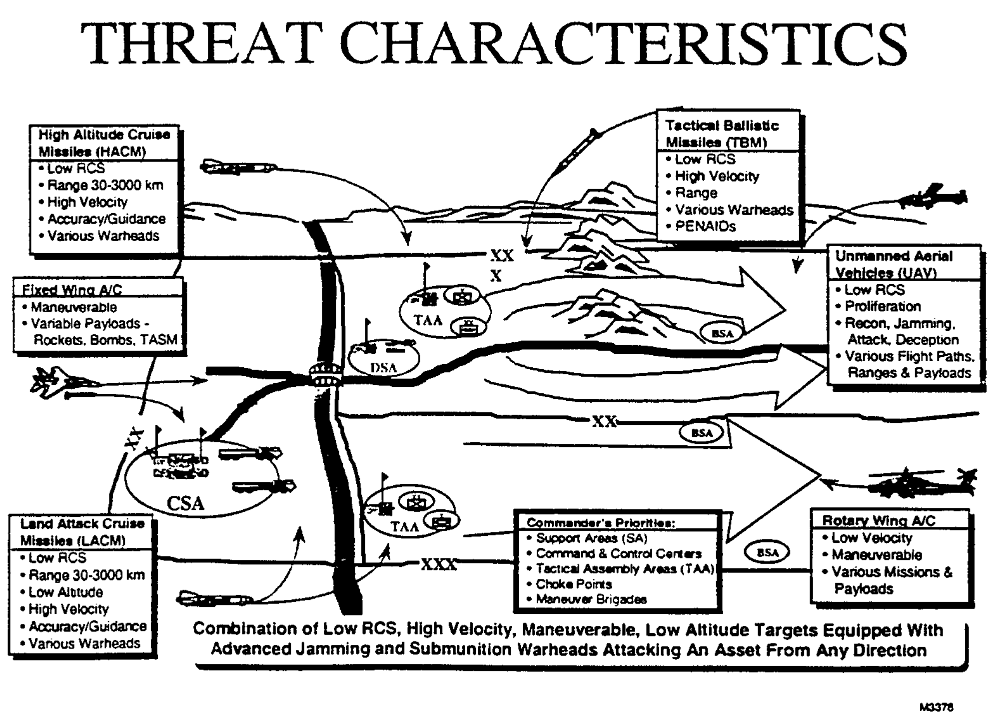

FIGURE 2: THREAT CHARACTERISTICS [12]

The most proliferated and inexpensive systems include LCRs and WMD-capable UAVs. These systems operate from reduced ranges and are difficult to defeat with "traditional" AMD systems outside the defended area (thus minimizing lethal effects on the ground). PAC-3 will be effective, but the anticipated cost of a PAC-3 missile is prohibitive if used to engage large numbers of short-range battlefield threats.

BUDGET IMPACT

This paper identifies knowledgeable sources stating that the Army requires more funding not only to maintain its existing structure, but also to enable investment in future capabilities. Figure 3 depicts the U.S. RDT&E and procurement budgets over 17 years and indicates the procurement budget will finally begin to increase. It also shows that the increase will partially come from a reduction in the RDT&E budget.

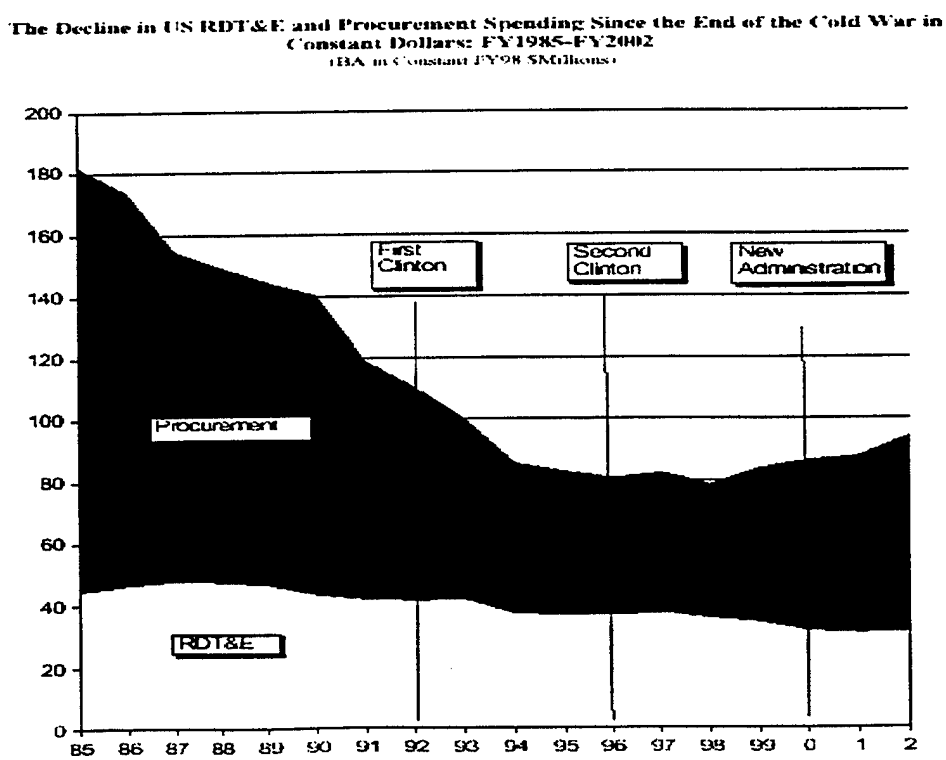

FIGURE 3: U.S. DEFENSE RDT&E AND PROCUREMENT BUDGET [13]

How can the Army purchase new technologies to ensure overmatch capabilities? Technology is advancing rapidly and is becoming more expensive to purchase, but it is also more readily available to our potential adversaries. As a result, the Army must establish strategies to get the most bang out of its R&D buck. A report to the CSIS Senior Policy Panel stated that, "...uncertainties regarding the future requires investments in R&D to protect against Technological surprise and to ensure that U.S. forces will always posses the best capabilities available. Maintaining and modernizing the U.S. military is both an expensive and, in a time of decreasing defense budgets and industrial downsizing, a highly challenging endeavor."[14] To develop a plan for getting the most out of our dollars and executing the budget, DoD's guidance comes from the National Security Strategy (NSS) and National Military Strategy (NMS).

NSS

The current NSS has three objectives: enhance U.S. security, bolster American economic prosperity, and promote democracy abroad. The first and last give life to a strong and well maintained military that can protect our national interests and exert itself when sent abroad. The military services produce the NMS to support the NSS.

NMS

The current NMS requires that the military *Shape* (the international security environment), *Respond* (to the full spectrum of crises), and *Prepare Now* (for an uncertain future), while retaining the capability to fight and win two nearly simultaneous major theater wars (MTWs). From this, the military develops its force structure, defines equipment needs, and develops doctrine, tactics, techniques, and procedures. Every year a new NSS and NMS should be developed. After eight years under President Clinton's administration, DoD is under the leadership of a new administration and may see some new changes to its strategies and missions.

Will the Bush administration's NMS continue to support two MTWs? The ability to support two MTWs is a long-standing debate. If the strategy remains, most military leaders recognize the second war would be high risk. The two MTW strategy is the driving basis for the Army's 10 active component divisions, the guard and reserve forces, and their subsequent equipping. Any changes in strategy impact the make up of the joint forces and affects plans for managing the overall R&D budget.

QUADRENNIAL DEFENSE REVIEW (QDR)

The QDR is a congressionally mandated top to bottom study of the DoD that is completed every four years by all new administrations. The review involves a comprehensive examination of defense strategy, force structure, force modernization plans, infrastructure, and other elements of the defense program and policies in order to determine the defense strategy of the U.S. and to establish a revised defense program.

The QDR is prepared at a critical time when the new administration is busy establishing its executive staff and cabinet, reviewing the current year's budget, and simultaneously preparing the next years budget; all while working to fulfill its campaign promises. The new SECDEF promised to complete a review of all military programs but regardless of his promises, the QDR will highlight modernization requirements to implement any changes to the NMS. The QDR is an involved process normally taking up to eight months to complete, which may result in recommended changes to the NMS and could place even more requirements on an under-funded R&D budget.

BALANCED BUDGET ACT (BBA)

In 1997, Congress passed Public Law 105-33 requiring the Government to balance the federal budget by 2004/2005. The purpose of the act was to bring revenues into balance with outlays. For the years from 2000 to 2005, Congress established a maximum deficit level. The

law establishes fines and penalties if the budget deficit does not stay under these limits. This requirement places additional barriers on the Government to adding large plus ups to the budget. In FY 1999, Congress increased the Army's budget by $612.5 million far less than the $1 – 2 billion requested, but it helped. The BBA places great restrictions on the Government and mandates a much smaller budget deficit. Despite the anticipated surplus, the Army can no longer count on annual congressional plus ups to meet its funding shortfall.

A DISCUSSION OF TECHNOLOGIES

Given the threat forecast, especially its sophistication and proliferation, continued AMD effectiveness depends upon advanced technology to provide continuous coverage of the joint maneuver forces. As stated by Major General Dennis D. Cavin, the Chief of Air Defense Artillery:

> "As the Army has begun a transformation, so has the Air Defense Artillery. The Air and Missile Defense (AMD) force will move, along with the rest of the army, away from large, inefficient, specialized organizational designs with embedded combat service and combat service support toward smaller, multifunctional designs. These new designs enhance tailorability and flexibility, making our transformed AMD force more responsive to Army and Joint/Coalition requirements. We will arrive at our destination equipped to defend the force against the full spectrum of the dynamic third-dimension threat, including, for the first time, rockets, mortars and artillery." [15]

"TRADITIONAL" TECHNOLOGY

Within the context of "traditional" systems, critical enabling technologies for 21st century AMD are divided into three technology areas – acquisition/track sensors (typically radar), hit to kill, and battle management, command, control, communications, computers, and information (BMC^{4}I).

ACQUISITION/TRACK SENSORS

Both current and projected AMD systems use advanced Radar technologies to acquire and track potential targets at extended ranges. Acquisition of WMD targets at long ranges is extremely important in order to insure verified targets can be destroyed far from defended areas or forces. Threat design and delivery techniques may present unique challenges for long-range acquisition and/or track sensors. These challenges may be overcome with "brute force" using large power/aperture radars or finessed with specialized high speed processing. These techniques may also be combined synergistically to further enhance capabilities. The right combinations result in the potential to reduce system size, complexity, and signature without reducing performance.

Forward deployed, long range sensors such as those proposed for MEADS will provide critical long-range target acquisition and cue forward-deployed SHORAD units.[16] Long-range target acquisition is typically limited by the ability of surveillance assets to see past the limits imposed by the earth's curvature. For this reason, organic airborne systems in development will act as adjunct sensors participating in the netted and distributed architecture and will enable "over the hill" engagements. These systems, like the Joint Land Attack Cruise Missile Defense Elevated and Netted Sensor (JLENS), an aerostat based system, will address the specific vulnerabilities faced from cruise missiles and other low flying targets; however, to accomplish this, they must also be equipped with the best acquisition and track radar technologies.

SYSTEM CONCEPT

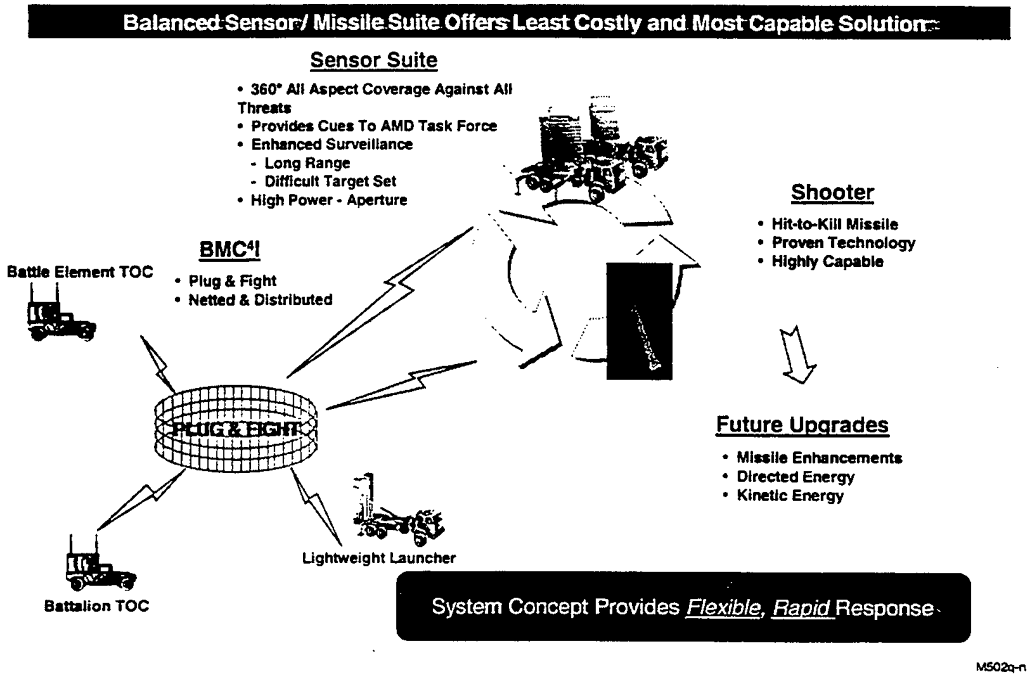

FIGURE 4: SYSTEM CONCEPT[17]

HIT-TO-KILL

The "crown jewel" of AMD technology is the ability to successfully "hit" a WMD target with sufficient mass and velocity to effectively destroy the target, resulting in no lethal effects reaching the defended area. The definition of "no lethal effects" on the defended area is dependent upon the particular WMD destructive methodology. Since payload discrimination is another difficult task, the user defines specific "keep-out" altitudes and ranges – effectively a "keep-out" volume, that should insure target intercepts are achieved at the range or altitude necessary to result in a success. For example, intercept of a ballistic missile carrying a bulk chemical warhead must be achieved with the proper combination of sufficient destructive force and altitude/range. This insures that any bulk chemical agent *not* destroyed upon impact is dispersed below the level of a lethal dosage.

HTK technology development enjoys a successful, but often overlooked, legacy that dates back to the Homing Overlay Experiment (HOE) in June 1984, and continues with the Flexible Lightweight Agile-Guided Experiment (FLAGE) in 1987, the Extended Range Interceptor Subsystem (ERIS), and Extended Range Interceptor (ERINT) Guided Test Flights 2, 3, and 4 in FY'94.[18] The PATRIOT PAC-3 and THAAD systems have both successfully intercepted threat-representative ballistic missile targets. HTK technology replaces the blast fragmentation warheads of current air defense missiles with point-to-point intercepts. "Sled" testing confirms that HTK increases lethality and successful target intercepts by providing superior energy and penetration and results in robust destruction of typical WMD warheads.[19]

BMC^{4}I

The electronic "glue" that is needed to conduct successful AMD engagements in a technologically advanced target environment is the most complex and arguably the least mature component of the required AMD system. The user defined the term "netted and distributed" to describe the next generation BMC^{4}I system. This development is the AMD equivalent to the digitization initiatives ongoing in the Army's modernization. AMD elements participate and are controlled through integration into a hierarchy of communications and data networks that extends from local nets (at the unit level) to the joint network architecture. The netted battle space is envisioned as a composite and common Singe Integrated Air Picture (SIAP) shared across all services and platforms.

The SIAP is envisioned as an integral part of Joint Vision 2010's concept of Network-Centric Warfare.[20] Army AMD assets intended to contribute and participate in SIAP include SHORAD platforms like the Sentinel Radar and Avenger System, medium range systems such as PATRIOT and MEADS, and longer range systems like the THAAD. Enabling a SIAP allows sharing composite fire control data with all AMD systems. The ability to share data frees

weapons from relying only on organic sensors, and permits engagements independent of the data source in a netted and distributed architecture.[21]

Advanced high-speed processing techniques are necessary to develop the distributed architecture that synergistically enhances system performance. Current generation AMD systems are site centered: sensors, command and control, and missile launchers are linked to form an independent fire unit. Engagements occur and are limited to using the assets within a single fire unit. External links are limited to command and control operations with neighboring fire units or higher echelon elements. A distributed architecture is not limited to the capabilities in a single fire unit. Target acquisition, track and engagement operations are performed using all assets in the netted environment. A "best track" is developed using composite or fused data from all acquisition assets, and the interceptor is fired from the most advantageous launcher. BMC^4I functions can be hosted from any BMC^4I node or Tactical Operations Center (TOC). Loss through destruction or other means of any piece of equipment is transparent to the system in a distributed architecture. The functions of any single element can be re-hosted elsewhere as necessary. This is unlike site-centered architectures where loss of any single element, such as the dedicated radar or TOC, results in loss of all assets within the fire unit. There are no single point failures in a distributed system.

"PLUG AND FIGHT"

The term "plug and fight" describes a critical capability of this advanced system. Much like the "plug and play" functionality of modern computer peripherals, the system architecture provides for self-initialization and real-time reconfiguration of available assets contributing to the AMD system. The AMD commander needs the capability and flexibility to task organize his force and support various mission and threat based defense design scenarios. "Rather than the system-centric and battery-centric organizations of today, the AD commander on the battlefield of tomorrow will reach into his 'tool box' of capabilities and deploy just the tailored mix of

sensors and shooters needed to perform the mission."[22] In the case of a force build-up, or as initial entry forces increase through available lift, more components may "plug-in" such that the netted and distributed defense grows seamlessly in capability and defended area. The defended area can be modified as necessary to accommodate situational changes through the simple addition or "plug-in" of the correct components: sensors, shooters or BMC^4I.

"LEAP-AHEAD" TECHNOLOGY

Leap-ahead technologies are those advanced capabilities that will revolutionize and augment current AMD capabilities by providing a low cost and highly lethal defense against all categories of threats. These capabilities require additional R&D, but once developed and tested, will provide an extremely inexpensive "bullet" that is effective against a wide array of threats. The most promising of these leap-ahead technologies include DE systems that destroy based on transferring and coupling sufficient energy into the target, and KE projectile systems.

DIRECTED ENERGY

DE systems must develop and transfer large quantities of energy from the point of origin to the target. DE "kills" can be *soft* – destroying electronic components – or *hard* – resulting in catastrophic damage to the target. Engagement of WMD targets requires the latter: it is insufficient to simply render a potential WMD carrier inoperative leaving the warhead or payload largely intact. Desert Storm demonstrated the results of simply deflecting a warhead over occupied areas. Although R&D in DE includes much of the electromagnetic spectrum, the most promising frequencies include microwaves and lasers. Microwaves tend towards soft kill methodologies and are extremely difficult to propagate across tactically significant ranges so are not practical as a viable solution in the near or anticipated far term. Lasers, on the other hand, are showing significant progress and success in anti-missile applications. On June 6, 2000, the Theater High Energy Laser (THEL) Advanced Technology Demonstrator (ATD) "knocked" a

Katyusha rocket out of the White Sands Missile Range sky.[23] THEL is a laser system developed in cooperation with Israel to address Israel's LCR threat. Speaking about this event, Lieutenant General John Costello, Commanding General, US Army Space and Missile Defense Command declared, "We've just turned science fiction into reality!"[24] It should be noted, however, that as early as the mid 1970's the Army conducted successful engagements against radio controlled subscale targets in flight using a carbon dioxide laser integrated into a Marine Light Assault Vehicle (LAV).[25] The point is this technology and application is not new, but scarce R&D funds have limited the pace of required developments in areas such as logistical support and power generation to the point that progress toward deployment is painfully slow.

KINETIC ENERGY

Modern HTK missile systems impart sufficient KE into a target but are extremely expensive to design and build. Missiles like the PAC-3 must incorporate on-board guidance, propulsion, communications, and warhead functions. Critical components of lethality are missile velocity, mass, and hit-point geometry. Relying on the missile itself to reliably accomplish the guidance and lethality required is a cost driver. A KE alternative offloads lethality and guidance functions from the missile/projectile. It relies upon a re-usable ground based system to perform guidance functions repetitively. Greater launch and target intercept velocities offset reduced missile mass, and simplified guidance and launch support systems reduce per-shot cost. Some warhead functions and complexity are eliminated. KE systems are designed around alternative propulsion technologies such as the electric gun.

DE and KE systems would be most effective against those "cheap and easy" but highly proliferated targets such as LCRs and loitering UAVs. These and other shorter range, slower, and less maneuvering targets tend to be more vulnerable to DE and KE kill mechanisms, do not require overly complex engagement management systems built into the ground systems, and thus are engaged more cost effectively.

The common threads between traditional missile systems and those considered leap-ahead are the target acquisition, track, and BMC^4I components. To over-simplify, the ideal system architecture would be 100 percent common ground support with the only differences in any engagement being the "bullet" and launcher selected: traditional HTK missile, DE, or KE. All could be combined in a future AMD task force operation to provide the most cost and operationally effective mix against the anticipated target array. The ADA school recognizes that organizational changes are necessary to accommodate changes in AMD operations and have already begun work on transformed organizations that are centered on functions rather than systems or batteries. These "sensor", "shooter", or BMC^4I elements better support mission specific task organization.[26]

ACQUISITION INITIATIVES

Transforming the ADA force to meet the timelines required is as challenging as it is for the rest of the Army. It requires the acquisition community to perform as expeditiously as possible to develop and produce those necessary systems without compromising safety or inducing cost. This process requires cooperation and compromise between the combat developers and the materiel developers if there is going to be an acceptable path to objective system performance.

SECDEF Rumsfeld said, "Simply tinkering with the present acquisition system will not provide the innovation and speed necessary to satisfy future military needs and take advantage of powerful new technologies…[it] is mired in unrealistic requirements that unnecessarily delay the time from concept to deployment at a time when technology is leaping ahead."[27] SECDEF Rumsfeld's view is shared by many acquisition professionals, and for good reasons. History is not on the side of transformation advocates for rapid systems development. Both the requirement and acquisition communities are strictly governed by regulation and process. This has also been recognized at the highest level of the military. As the Vice Chief of Staff, Army,

General Keane recently stated, "Acquisition reform is a very important part of where the Defense Department is moving, and it's essential to the future of Army Transformation."[28] If transformation is going to be successful and timely, several initiatives are necessary.

NEW DOD 5000 SERIES

DoD guidance governing major acquisitions, the DoD 5000 series, was revised and approved on October 23, 2000. This revision incorporates evolving changes to the process and allows increased flexibility in reaching objective system performance requirements. Close coupling of the combat and materiel development processes remains, but some of the constricting edicts from the previous instructions were relaxed to allow greater acquisition flexibility and further technology maturation before finalizing performance requirements. For example, the requirement for final approval of the Operational Requirement Document (ORD) has been moved to later in the process; no longer binding the developer so early in the development that unanticipated innovation and technology advances are not considered or incorporated. This also allows cost and performance trade-offs to be accomplished as the development progresses. Significantly, system *affordability* is now considered as an operational requirement.

A major change to the guidance includes separating "technology" from "system" development. This separation is intended to place greater emphasis on mature technology, and insure programs enter the single system development phase with matured concepts and technologies. It recognizes Low Rate Initial Production (LRIP) as a more important DoD commitment than Full Rate Production (FRP). Much greater emphasis is placed on Interoperability. An overall intent of the changes is to facilitate decisions based on demonstrated performance rather than the process itself. Higher performance, lower costs, and more rapid deployment are the intended results.

SPIRAL DEVELOPMENT

Complex and extremely capable DoD systems require significant development and test activities to meet demanding requirements and insure safety and performance. One approach to get capability into the field as early as possible has been to undergo "spiral" or evolutionary developments. That is, develop, properly test, and field basic system capability, and then later provide full performance through a series of fully developed upgrades or enhancements. This block upgrade approach allows system fielding at its earliest possible time unencumbered with issues associated with the most complex or demanding capabilities. Enhancements are usually full-performance attributes that are also the most expensive, controversial, and time consuming to complete.

COST AS AN INDEPENDENT VARIABLE (CAIV)

CAIV is another development process that is used extensively in DoD today. CAIV recognizes that funding is limited and once allocated in the budget process, generally fixed in today's R&D environment. While all approved requirements remain valid, when affordability is considered against the incremental cost of some aspect of performance, then it may be necessary for the user to accept some limited trade-off of requirements for cost. The CAIV process relies extensively on modeling and simulation (M&S) for the evaluation of potential trades. CAIV requires close partnership between the user and the materiel developer since any performance trades in the interest of affordability will require the user to evaluate and accept a certain level of risk associated with the trade. A summary example of the extensive trade analysis conducted by the Product Manager (PM), U.S. MEADS is included in figure 5. Trade space was defined that related to the system performance envelope and eventually resulted in a recommendation to adopt the PAC-3 missile as the MEADS interceptor. This recommendation

was finally adopted following the results of the extensive MEADS Analysis of Alternatives (AOA), but the technical basis was developed as a CAIV assessment.

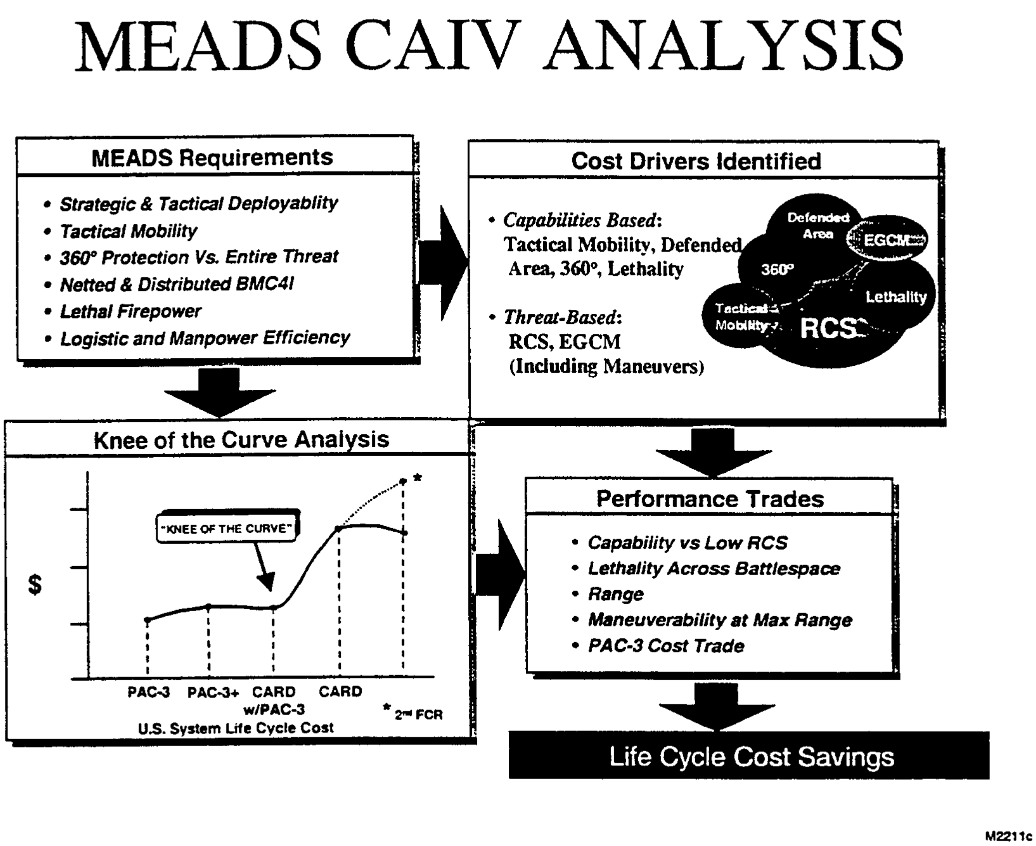

FIGURE 5: MEADS CAIV ANALYSIS [29]

MEADS CAIV analysis focused on identifying the system cost drivers. A demanding basic requirement set included capabilities like C130 roll-on/roll-off and 360 degree lethality against the demanding, difficult to detect targets with low radar cross sections (RCS). Cost drivers were identified as either desired system capabilities or necessary to defeat specific threat characteristics and ranked according to cost impact. A "knee of the curve" analysis compared increasingly capable system configurations (and therefore levels of performance) against system life cycle cost. The results identified a point on the curve where the system was most cost effective – additional small increases in performance resulted in significant cost

increases. The user evaluated the risk associated with a slight reduction in system performance against the threat and agreed to trade-off some performance and accept the associated risk. The result was significant life cycle costs savings.

The CAIV process must be continued as a development continues; unanticipated cost increases in a fixed budget environment may require additional trades to maintain deployment of basic system performance. Any CAIV trade-off results in additional candidate technologies or performance enhancements considered for spiral system development.

DEVELOPMENTAL TESTING/OPERATIONAL TESTING (DT/OT)

Extensive testing, both DT and OT, is necessary in the modern acquisition process. Recent studies, including the Welch commission report on Reducing Risk in Ballistic Missile Defense Flight Test Programs conclude that multiple schedule slips and cost overruns can be traced directly to inadequate test programs and recommends extensive end-to-end ground testing of all flight hardware before flying.[30] The Government Accounting Office (GAO) released a report in January 2001 that blames THAAD's highly compressed flight test schedule for eventual flight test failures.[31] GAO claims that the schedule did not allow for adequate ground testing to detect problems prior to flight tests and also left insufficient time for preflight testing, post-flight analysis, and corrective actions.[32] Testing is expensive and time consuming, but a rigorous and comprehensive test program results in fielding a system with fewer problems and eliminates failures. The test-fix-test methodology of past missile system developments is expensive and only addresses those problems that arise in the flight test matrix. Philip E. Coyle III, the Director, Operational Test and Evaluation, OSD, addressed the concern for DT in evolutionary developments with a series of questions:

"Seven Ways to Know if You Are Placing Your Program at Unnecessary Risk."

1. Are you taking too much schedule risk?
2. Are you going into operational testing before you are ready?
3. Are you loading your system realistically in developmental testing?
4. Are the requirements for each block set properly?
5. Are you skimping on developmental testing?
6. Are you using modeling and simulation effectively?
7. Are you including the operational testers up front?[33]

Coyle concluded, "Don't Skimp on DT, because if you do it will kill you when you get to OT." [34]

The acquisition initiatives discussed above are critical to the success of any modernization program that is under schedule pressure. Spiral development has now become the standard due to demanding requirements, the resulting system complexity and the immediate requirement to get baseline capabilities in the field. The newly minted DoD 5000 specifies evolutionary acquisition based on time-phased requirements as a means of insuring technology is not "locked down" too early and that new technology developments are incorporated as they mature. The continuous analysis associated with CAIV planning provides the basis for affordability trades, and the M&S work for the CAIV analysis becomes the technical basis for M&S in the DT/OT test phase. Each test evolution in the system development process has to be carefully designed, and should take an integrated approach early on to reduce test cycle time and increase synergies between the DT and OT activities.

INDUSTRY ISSUES

Although the Federal government historically funds the bulk of R&D, the DoD has always had help from the DIB to offset its costs. However, over the last decade even defense industry R&D investment has shrunk in real terms.

PROFITABILITY

The defense industry is largely a privately owned institution, and as such, it must remain profitable to attract investors. Investors' infusion of money gives industry the cash required to purchase facilities and fund R&D. Until recently, performance of defense stocks has been poor in relation to other high tech stocks, and this has reduced the amount of cash available to the DIB. Discussion of increased defense spending during the presidential race and this year's poor technology stock performance pushed defense stocks back up slightly and seems to have reversed the trend. For example, Boeing stock is up 47 percent, Lockheed Martin is up 56 percent, and Raytheon is up 24 percent.[35] The following chart from the DoD's FY 2000 Annual Capabilities Report to Congress shows that defense stocks have lagged compared to Standard and Poor's 500 in the late 80's and early 90's and also shows its recent up turn.

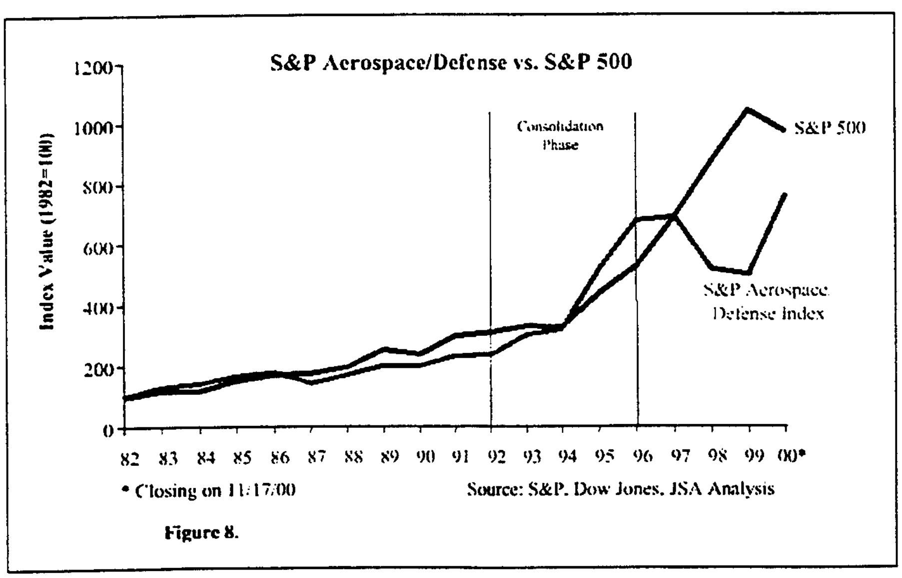

FIGURE 6: DEFENSE STOCK PERFORMANCE[36]

The down turns of the 80's and 90's tightened defense industry liquidity and contractors generally were unable to fund facility improvements and invest in future technologies. Industries could only invest in specific, narrowly focused areas with quick payback and ultimately profit for stockholders.

R&D INVESTMENT

Stockholders demand a return on their investments or they will likely sell their holdings and re-invest in an industry bringing them a better return. The realities of long lead-times between the funding of research and its translation into products keep companies from making some long-term investments. Companies must perform for their investors and produce profits. Uncertainties associated with government procurements do not readily translate into contractor willingness to pay for the R&D required to give the U.S. military its technological edge.

Figure 7 depicts a strong stock market recovery for the defense industries, however the same DoD report to Congress stated,

> "... the aerospace/defense sector has not kept pace with an overall improvement in profit margins within other technology industry sectors, and this has put the defense industry at a disadvantage in attracting investment capital and qualified people. DoD is considering what steps it should take to improve its acquisition and technology procurement system to enable aerospace/defense firms to grow their business, improve profit margins, and attract capable scientists and engineers."[37]

Once these steps are defined and DoD pursues these measures, then the DIB may be able to increase their R&D budgets and help fund more of tomorrow's technologies.

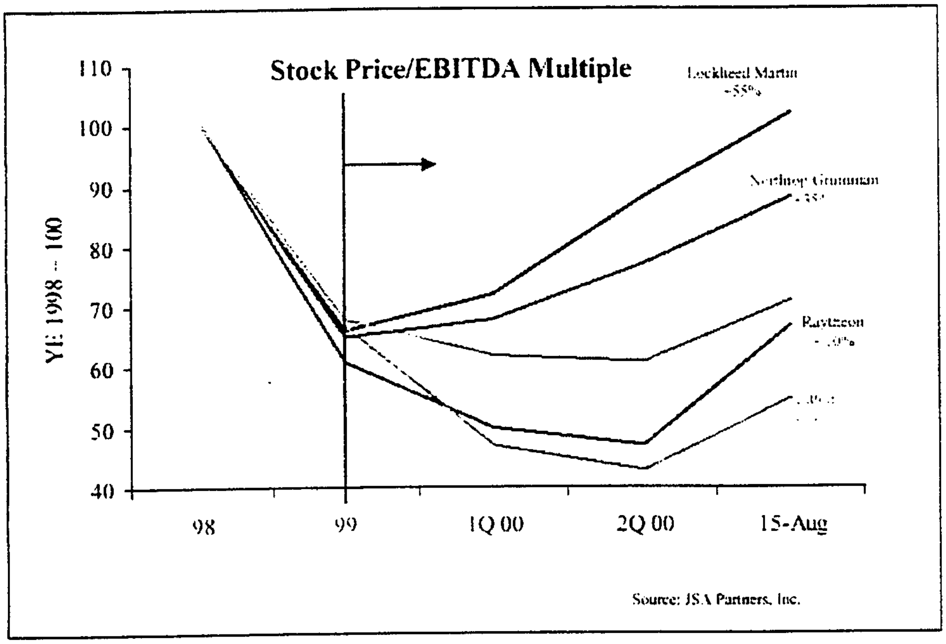

FIGURE 7: DEFENSE STOCK TRENDS [38]

COOPERATION/CONSOLIDATION

Economic realities of the 1990's forced the numerous defense contractors to chase after a smaller defense budget. Typical of a classic business model, a phenomenal shake-up of the defense industry resulted. There were acquisitions, mergers, hostile takeovers, and bankruptcies producing a consolidation of the industry, resulting in a small number of large prime defense contractors. Additional corporate downsizing and restructuring followed. Today, although defense companies are fewer in number, they remain integrated and broadly capable. Company resources and experience continue to dwindle as they pursue limited opportunities for DoD procurement and R&D budgets.

Partially caused by different acquisition strategies employed by the DoD, and partially because of economic factors, defense contractors were forced to partner, team, or form joint

ventures with their competitors to capture (win) new defense contracts. Today, many prime contractors team with other contractors to produce the equipment purchased by the military. These arrangements are advantageous in the sense that DoD is still able to contract for the high quality products and services it needs.

An overall result of the defense consolidation has been to reduce the opportunity to benefit from many of the advantages of increased competition. With an extremely limited number of potential vendors, the DoD enjoys fewer competitive procurements and therefore fewer opportunities to reduce cost. If there is only one qualified manufacturer for a component or end item then DoD has little leverage to drive down costs.

Proprietary issues also plague the defense contractor consolidation. Typical of procurements today, an industry team will rely on its members to produce components in their functional areas of expertise. For example, one company may produce the airframe of an aircraft, another the weapon systems, and a third the avionics. The defense contractors are very careful not to share their manufacturing or technology process secrets. There is no cross-fertilization of advanced manufacturing processes or product development. The contractors are cautious of industrial espionage and a loss of technological superiority. All vie for the technical lead position of system integrator. They know that on the next defense contract they might not be a party to the next production run if they are not the recognized leaders for delivering their product or the only company capable of providing it to DoD. Often, a defense contractor will share technology with the government, but not other contractors.

TECHNOLOGY CONTROL

Achieving and maintaining technical superiority are two separate concerns. The U.S. has achieved overmatch capability through technology developments and system enhancements. This lead is precious to the DoD and is closely protected through a myriad of regulations. The U.S. becomes concerned whenever cooperation with other nations results in transferring

technology to those nations and therefore potentially reduces our technology lead. This concern is not necessarily with the cooperating nations, but rather with the potential for third party transfers. Technology transfer to other nations is heavily screened and controlled through State Department oversight and an extensive export licensing process. Export licensing is cumbersome and time-consuming but it insures that each release is carefully screened for its impact. While foreign cooperation and investment in R&D is a viable means of gaining funding, the benefit must be closely weighed against the potential loss of technical superiority to other nations.

RESEARCH AND DEVELOPMENT FUNDING STRATEGIES

The bottom line recommendation is to use any funding strategy that results in either an increase in the funding available to transform ADA or provide a more efficient use of limited R&D funds to the same end. There is no single right answer or recommended approach for the Army in general and the ADA community in particular to use in dealing with the dilemma of a finite and under-funded R&D budget versus an ambitious AMD requirement. The following is a comprehensive, but certainly not all–encompassing, discussion of alternative strategies developed to attack the issue. All strategies presented are viable and should be applied in accordance with whatever facet of the particular requirement it fits.

(1) BUDGET INCREASE

The most logical and obvious solution for fixing any funding shortfall is to seek a plus-up to the President's budget request. Concerning ADA transformation initiatives, this option is problematic. During his presidential campaign, Mr. Bush promised to increase the DoD R&D budget by 20 percent – drawing from a robust budget surplus prediction. Annual increases to the president's budget are possible, but usually require a champion in Congress. One example is the PATRIOT multi-mode missile program. Despite losing in head-to-head competition with

the PAC-3 HTK missile contractor, the multi-mode missile contractor is able to obtain annual Congressional plus-up funding and program direction despite having no operational requirement, and no Army or OSD annual request for funding. This has kept a multi-mode missile program "warm" since the down-select decision for PAC-3. However, annual congressional plus-ups are never guaranteed, particularly now in light of the BBA. It is not feasible, therefore, to plan a major program around an annual promise of funds, but it is prudent to keep a "hip pocket" list of unfunded requirements should the opportunity arise. An example of one such "minor" funding issue is the development of a lightweight launcher for the current PATRIOT system. This single initiative would seriously reduce the airlift required to deploy a PATRIOT unit.

In fact, it is extremely difficult to garner funds outside of the budget submission and approval process. The system of annual appropriations and Future Year Defense Plan (FYDP) insures that programs need to be inserted early in the planning process. The reality is that any significant R&D budget increase will probably come at the expense of some other critical account and is therefore unlikely unless the political climate and subsequent national security or national military strategies change. Recently, former Defense Secretary William S. Cohen stated that he believes that the budgetary projections are going to be "quite positive in terms of what President-elect Bush will have available, but I think even more will be necessary."[39] However, in a February 3, 2001 article *Reuters* reporter Charles Aldinger reported, "The White House indicated earlier this week that there would not be any major increase in the nation's $310 billion defense budget despite promises by Bush during the recent campaign to sharply upgrade the military."[40] Mr. Aldinger went on to say that the President was going to wait for the Defense Secretary's "sweeping review of America's defense strategy" before he made any large adjustments. Increasing DoD's R&D budget for AMD may not turn out to be a feasible strategy.

(2) REDUCE OTHER DEMANDS

Another strategy for increasing the R&D budget is to reduce military commitment to other activities not considered necessary to the NMS that require defense funding. Freeing up these dollars permits the military to reprogram funds into the R&D account. Just as the defense industry has consolidated and eliminated their redundant or over-capacity facilities, the military must eliminate facilities and infrastructure it no longer needs. Since 1990, the military has reduced its forces by over 34 percent, but has just scratched the surface for eliminating bases and outsourcing non-critical DoD personnel and activities. If the Defense Department could gain congressional authority to close redundant facilities and outsource functions now performed by government personnel, O&M requirements would shrink and thus increase the potential for R&D funds. SECDEF Rumsfeld recently said, "The legacy of obsolete institutional structure and processes and organizations does not merely create unnecessary cost . . . it also imposes an unacceptable burden on national defense. It could be said that we are in a sense disarming or under-arming by our failure to reform the acquisition process and to shed unneeded organization and facilities."[41] Keeping open unneeded facilities places a large, wasteful requirement on the Defense Department and consumes funds that are desperately needed in other places.

However, Congress continues to oppose OSD pressure and recommendations for measures eliminating unneeded bases. The 2001 Defense Authorization Bill did not support President Clinton's proposal to authorize two additional rounds of base closings. Members of Congress are unwilling to close installations that affect their constituencies. Changing this requires a concerted effort by the President and the military's civilian leadership to convince Congress that some installations are redundant and impose an unneeded drain on the defense budget.

(3) DEPEND ON COMMERCIAL INVESTMENT AND ADVANCES

Many of the technological advances Army ADA needs can and will come from the commercial sectors. In a CSIS report, Mr. Schlesinger reported,

> "At one time, in the first few decades after World War II, the government, and particularly DoD was the main source of sponsorship and financing for national research and development. The U.S. Government supported and directed programs that produced the basic technologies that led to numerous military and commercial innovations. Since 1981, private sector investment in R&D has out paced government investment. The sources of the innovations, which will serve as the basis for the military capabilities of the 21st century, are more likely to reside in the commercial sector than in a unique defense industrial sector."[42]

Recognizing this trend, the Army must seek out and monitor innovative commercial technology that could be purchased for its use.

This strategy suggests DoD should not invest its finite R&D budget without thoroughly investigating similar commercial market technology developments. In fact, the DoD should continue to encourage commercial investment in technologies useful for military applications. Awareness activities such as directed briefings to industry are effective in this regard. Industry sectors such as computers, satellites, and communications produce technologies that are directly applicable to DoD requirements and should be actively encouraged. Development of basic capability such as processors and semiconductor chip sets can be left to industry to produce and then purchased for military applications. The DoD needs only to insure that these COTS products are modified as necessary to perform in the military environment.

The AMD critical technologies previously described are well suited to this strategy. Radar component and software designs, missile-resident processing, and the architecture-intense BMC^{4}I elements benefit from commercially developed technical advances. One of the fastest growing commercial sectors, wireless communications, is a particular example of commercial requirement driven technologies that are useful in military applications. The very idea of a "plug and fight" system architecture is a direct extension of the "plug and play"

computer peripheral designs that simplify the complicated serial/parallel interfaces of the last generation state-of-the-art technology. AMD system prognostic/diagnostic capabilities specified in the MEADS ORD are similar to those now appearing in automotive support applications. Cadillac's "OnStar," a rudimentary but effective system, combines cellular communications with global positioning system (GPS) functionality. Besides convenience functions, it provides immediate remote diagnostics of the vehicle's engine, power train, and brakes if a warning light illuminates.[43]

(4) USE STRICTLY COMMERCIAL TECHNOLOGY

The commercial sector is highly competitive. Because it responds to economic demands, it is more agile, flexible and responsive to change. Private sector firms develop increasingly sophisticated products in significantly less time and at lower cost. This is particularly true for the electronics and computer sectors, which are the leaders in high technology innovation. These sectors are vital to the development of high-performance intelligence, reconnaissance, surveillance, and target acquisition (RSTA) systems and BMC^4I systems the Army requires.

The new acquisition guidelines, outlined in the DoD 5000 series, specify preference for COTS products over those developed from scratch exclusively for the military. The military has seen that COTS capabilities can make substantial contributions to technical performance, reliability, and cost reduction. This strategy recommends that the Department pursue savings by first looking for commercial technologies or products that meet performance requirements without further development. This is true off-the-shelf functionality and may necessitate some relaxation of extreme environmental ruggedization typical of military specifications, as suggested by a CAIV approach to development activities. Similarly, modest investment to modify a commercial product should be considered before committing to a full development.

(5) PARTNER WITH ALLIES

Another way to stretch the DoD R&D budget is to cooperatively team with allies that share similar operational and functional system requirements. Combining our allies' investment with our own results in the ability to purchase more and helps to modernize our allied partners at the same time.

The U.S. is not the only nation that has cut back on its R&D budget. Figure 8 shows the depression of the modernization budgets of the U.S. and North Atlantic Treaty Organization (NATO) -Europe. [44]

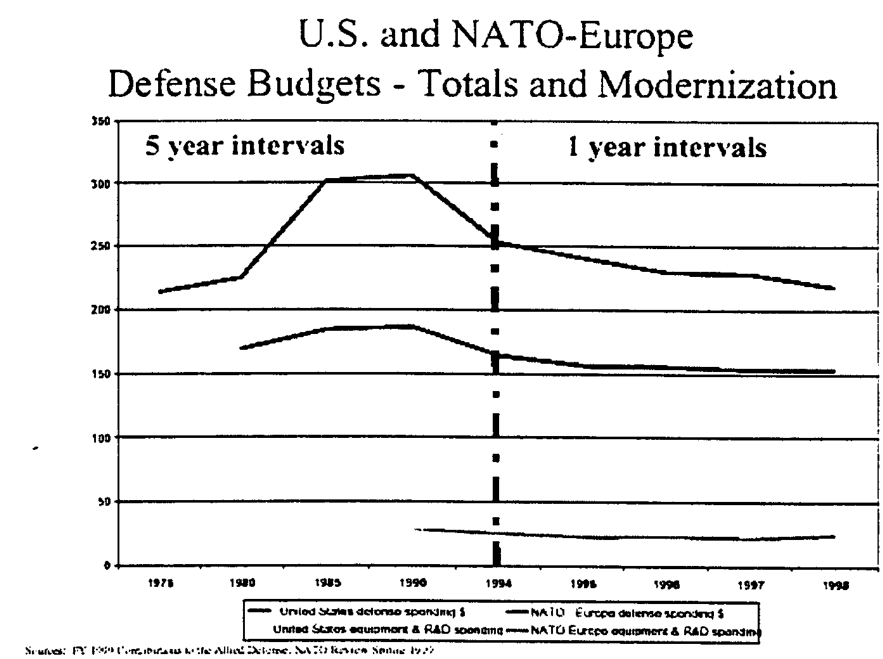

FIGURE 8: U.S. AND NATO- EUROPE DEFENSE BUDGETS

Working with U.S. allies, the DoD can combine funds and purchase more R&D aimed at Army AMD modernization. This funding consolidation would avoid waste where the U.S. and its allies are developing similar products or systems. NATO desires cooperative developments for both fiscal and political reasons. The Senior Military officer in NATO addressed the U.S. Congress in 1997 on "The Imperatives of Allied Defense Collaboration: The Case for MEADS." He reasoned that working together provides significant advantages to both the U.S. and its NATO allies. The United States could acquire many things at reduced cost and, for their part, European nations could afford the latest technology at manageable costs and in reasonable time.[45] Allied cooperation brings considerable risk in the area of technology transfer, but given agreement from the beginning on common operational requirements, is a viable means to concentrate scarce resources.

Successfully completed cooperative "mega-projects" include the NATO HAWK Missile and NATO Airborne Warning and Control System (AWACS). MEADS, a cooperative development with Germany and Italy, represents the future of AMD for the three partner nations. The system operational requirement is entirely agreed upon between the three nations. This system was designed considering the key concepts that now make up the transformation initiatives, including mobility, transportability, lethality, and flexibility. It incorporates the BMC^4I backbone for the ground contribution to SIAP, and is the critical link between SHORAD and THAAD assets, providing continuous coverage of the joint maneuver forces. Cooperative development also brings the advantage of built-in interoperability with the cooperating countries. Once developed, the project anticipates selling MEADS extensively to other NATO nations now relying on the aging HAWK system for organic air defense. The draft Memorandum of Understanding (MOU) for MEADS (due for signature upon this writing) stipulates the R&D cost and work shares for the participants: 55 percent U.S. / 28 percent Germany / 17 percent Italy. The U.S. pays just slightly more than half the cost and receives the full development of this critical AMD system. [46]

(6) POOL SERVICE R&D BUDGETS

Similar to cooperative developments with other nations, combining R&D budget elements within U.S. services for similar requirements would yield R&D budget dividends and eliminate separate service funding of redundant R&D efforts. Joint developments are difficult to manage due to service parochialisms and require up front agreement on operational and functional requirements. Some compromise is typical. This strategy may not lend itself to whole system developments in AMD since service mission areas are fairly well defined. For example, the Army defends Army and Marine Corps land based and operating forces, and the Navy defends over water and the littoral regions. However, *subsystem or component* developments share similar technical and functional requirements and their developments should be combined wherever possible. Potential component examples include advanced radar elements such as transmit/receive (T/R) modules, missile guidance and propulsion, and BMC^4I components that share the same function. In some cases, these common system elements differ only in their packaging requirements for different service applications.

This strategy also anticipates the Army seeking technology and applications from other services first before embarking on new developments. Even if modifications are necessary, the extent and cost of those modifications should be evaluated for savings potential. In many cases, slight changes to existing hardware or technology would suffice, thus eliminating costs and reducing development time. A hypothetical example would again use radar technology. A T/R module developed for use in a maritime environment considered for a land-based application may only require modification to eliminate added protection against salt spray – or may require no modification at all.

Service cooperation in AMD would be strained by the ongoing fight for mission area control between all three of the services. The services often dislike joint funding arrangements because they fear losing control and system sub-optimization. For this reason, inter-service

cooperative efforts may require direction from OSD to implement. Simply achieving agreement on mission area lead has the potential to increase Army funding from OSD for AMD program developments.

(7) PARTNER WITH ACADEMIA

Although industry investment accounts for approximately 65 percent of today's total R&D funding, DoD is still the primary investment source for advanced technology in long-term, high risk R&D. The reason for this is that industry must continually turn a profit and if their R&D fails to produce results or does not bring a product to market for many years, it will be unable to attract investors. For these reasons, the DoD allocates part of its limited R&D budget into this area.

Long-term, high risk R&D investment may best be spent at the nation's leading research universities. Universities do not have to respond to stockholders or turn a profit, and they typically have the time and resources to spend on developing new technologies. Universities employ, and support research by, some of the best-trained and highly educated scientists and generally have better access to commercial industry capabilities located within their cities.

Universities often get additional research donations from commercial industries, interest groups, and private citizens and by combining these donations with the DoD's allocations they can complete a great deal of research. The DoD should make a concerted effort to visit the best universities on a periodic basis, and encourage academia to pursue technology vital to U.S. military capabilities. The DoD should forge partnerships with universities and allocate R&D funding to those schools showing the most innovation and promise.

(8) USE EXPERIMENTATION AND MODELING & SIMULATION

This strategy merely restates an imperative for today's R&D environment: using experimentation and M&S properly saves or stretches the purchasing power of R&D dollars.

During his testimony before the Senate Armed Service Committee on January 11, 2001, SECDEF Rumsfeld said, "I see experimentation playing an important role. But let me be clear: experimentation will yield changes in course, exhibit failures of expectations, or even reveal past mistakes. We must be careful to learn from experimentation, and acknowledge the risks it reveals."[47] The SECDEF obviously recognizes the potential benefits of experimentation. His testimony implies that he understands that using M&S tools could show that systems programmed for large R&D investments may not work at all. Learning this through experimentation and M&S aids the military by demonstrating early in the acquisition process that the desired results may or may not be possible, thus providing keen insight to support R&D technology investment decisions.

Military experimentation has been employed for years. In the 1990s, the Joint Forces Command (JFC) was established placing forces from all services under one CINC. This organization owns all forces and equipment and has the ability to jointly experiment with new equipment and doctrine. OSD provides an experimentation budget to JFC, however, for FY 2001, it is less than $50 million.

M&S is a cornerstone activity in today's acquisition environment. It should be used to verify performance projections, estimate system operational effectiveness, and provide a digital environment to evaluate the impact of system design or operating environment changes on the anticipated performance envelope. Today, the PAC-3 flight test program includes a full-up digital simulation facility that conducts virtual engagements, mimicking each flight scenario multiple times prior to actually firing either the target or the interceptor. This facility is able to accurately predict missile performance, hit point, and lethality. Operators combine the actual ground support equipment hardware-in-the-loop (HWIL) until the point of launch and then "fly" the virtual missile via simulation. The MEADS program incorporated a similar simulation in its initial development. One requirement of the solicitation was successful development and demonstration of a full-up end-to-end digital simulation of the entire system. This simulation

forms the basis for further system performance evaluation and continues into the advanced development phases.

(9) TEAM WITH DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)

This strategy has already been implemented for ground forces transformation but is included here because of its high potential payoff as a general approach to garnering additional investment and its further application to the AMD mission area.

DARPA's mission is to pursue imaginative, innovative, and usually high-risk research ideas. They pursue ideas that offer a significant technological impact and take these ideas from the demonstration of technical feasibility stage through the development of prototype systems. DARPA programs typify "leap-ahead" technology developments, such as DE or KE programs and often do not adhere to traditional approaches to solve operational requirement shortfalls via technology enhancements.

Last year, the Army signed a memorandum of agreement with DARPA establishing a collaborative effort to develop and demonstrate the Future Combat System (FCS) for use in the Army's Objective Force. This ambitious project hopes to exploit breakthroughs in technology that can be rapidly integrated into a force with an initial operating capability (IOC) of 2010. Funded with $510 million from the Army and $406 million of its own funds, this is DARPA's largest-ever collaborative effort. DARPA, in cooperation with the Army, contracted with four contractor teams to develop concepts for the FCS, and in 2003 will down-select the best technologies and concepts for entry into a design and demonstration phase.

This approach offers the potential for high payoffs for the Army. The "bow wave" of procurements in front of the Army mandates that it take new, insightful approaches for acquiring the necessary technologies. Teaming with DARPA, an agency with the mission to develop high-risk technologies, and getting them to contribute a portion of their own budget to acquire the technologies for Army success is an excellent approach.

RECOMMENDATIONS

The Army must approach the management of its R&D budget from as many different angles as possible. It must use innovative acquisition initiatives, allocate the budget wisely, and work closely with academia and industry. The Army needs to work through its civilian leadership – requesting authority to outsource and eliminate redundancies – but ultimately it must convince Congress and the Executive Branch that, given today's NSS and NMS, these R&D accounts must be increased.

These recommendations are based on the premise of making the most efficient use of limited resources and producing the most advantageous results. Some are obvious – the Army cannot forget that the current PATRIOT-based AMD force is the only proven capability against the described threat set, and thus first priority has to be to insure modernization efforts keep that system up-to-date until replaced by the next generation AMD. An equal priority is to provide technology or engineering that will maintain the availability and relevancy of AMD to the transformed Army as it participates in joint maneuver and engagements. This clearly calls for reducing the physical equipment footprint (weight and cube) by producing lightweight C130 transportable equipment. Reduced size and weight result in an ability to provide greater force protection for equal lift compared to today's AMD forces, or the option to bring more capability and firepower with the same amount of lift. The ADA mission of force protection results in a first-in-last-out mindset, but at the build-up pace envisioned for a transformed Army, ADA will not be relevant unless the ADA transforms.

Next priority is to develop capabilities that address countermeasures to the emerging and proliferating WMD-capable air and missile threat array and, subsequently, to further develop those leap-ahead technologies that have the potential to significantly reduce the cost to operate and sustain AMD forces. Expensive, high performance "silver bullets" must be replaced with low cost interceptors or other WMD neutralization processes to be affordable and cost effective.

The Army should:

- pursue the R&D funding strategies presented here to maximize the potential of all available fiscal resources and generate additional resources through synergy and innovation.
- maintain viability of current AMD systems and actively pursue cost and size reductions insuring the near-term relevancy of ADA.
- continue developing the next generation of AMD as replacement to the rapidly aging legacy systems and adopt an evolutionary acquisition process to bring that capability to the field as rapidly as possible.
- develop leap-ahead technologies that revolutionize AMD and address the critical issues of affordability and cost effectiveness.
- engage in vigorous M&S to aid development of technology, systems, and doctrine and continue to support experimentation initiatives as a means to integrate into the joint force.
- pursue innovative acquisition processes to include adopting commercial practices and embrace evolutionary developments to field capability as soon as possible and upgrade with advanced technologies and enhanced capabilities as each mature and the threat proliferates and becomes more sophisticated.

CONCLUSION

There is little probability that the Army will ever receive all the R&D funds it needs. The Army must continue to work to get the most from the R&D budget. This paper has provided background into the R&D dilemma, discussed technological issues with R&D, presented industry R&D issues, and most importantly reported on a number of strategies for dealing with

the R&D funding shortfall. It should now be apparent that there would not be one simple approach for addressing this funding limit.

Mr. Rumsfeld, echoing the view of President George W. Bush, said he favored big increases in defense spending to help develop a modern military that, by its very might, could deter attacks.[48] This statement by the new SECDEF may have the military "leaning forward" in anticipation, but the reality may be quite different. The authors contend the best approach for the Army and its ADA component is to pursue the strategies presented in this paper in order to maximize the impact of every dollar appropriated for R&D.

ADA must continue modernization or become irrelevant in a transformed Army. Advances in technology will enable full ADA integration into the Network-Centric future Army. ADA will both contribute to and benefit from the synergistic defensive effects of the jointly shared Single Integrated Air Picture. Leap-ahead technologies will insure the continued relevancy and importance of ADA by creating affordable, cost effective alternatives to defeat the threat.

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